Prepared in cooperation with the
FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION, SOUTH FLORIDA WATER MANAGEMENT DISTRICT,
PALM BEACH COUNTY, MARTIN COUNTY, JUPITER INLET DISTRICT, LOXAHATCHEE RIVER ENVIRONMENTAL CONTROL DISTRICT,
TOWN OF JUPITER, VILLAGE OF TEQUESTA, JUPITER INLET COLONY, U.S. ARMY CORPS OF ENGINEERS

INTRODUCTION

The Loxahatchee River estuary, in southeast Florida, empties into the Atlantic Ocean at the town of Jupiter (fig. 3). The estuarine system is composed of three forks—southwest fork, north fork, and the northwest fork, which has the longest reach and is the main prong of the system. The three forks converge approximately 2 miles upstream from the Atlantic Ocean. Between the confluence of the three forks and the ocean at Jupiter Inlet, the estuary is intersected by the Intracoastal Waterway. Estuarine conditions extend from Jupiter Inlet to about 5 river miles up the southwest fork, 6 river miles up the north fork, and 10 river miles up the northwest fork. The upper reaches of the southwest fork were obliterated by construction of Canal 18 (C-18) built in 1957–58.

Since the turn of the century, the Loxahatchee River basin has been altered so by man that almost all the natural drainage patterns of the basin are now affected. Much of what was once marshland (Davis, 1943) is now a network of drainage canals, ditches, roads, super-highways, well-drained truck farms and citrus groves, and residential and recreational developments (Vines, 1970). The drainage network has lowered ground-water levels (fig. 2) and significantly altered surface-water inflow to the estuary.

Alterations along the coast have also affected the Loxahatchee River estuary. The natural mouth of the estuary, Jupiter Inlet, has opened and closed many times as a result of natural causes. Originally, the inlet was maintained open not only by flow from the Loxahatchee River, but also by flow from Lake Worth Creek and Jupiter Sound. Near the turn of the century, some of this flow was diverted by creation of the Intracoastal Waterway and the Lake Worth Inlet, and by modification of the St. Lucie Inlet (Vines, 1970). Subsequently, Jupiter Inlet remained closed much of the time until 1947, except when periodically dredged. After 1947 it was maintained open by dredging (U.S. Army Corps of Engineers, 1966).

The Loxahatchee River estuary system is important to this area of the State for its esthetic value and for its sport fishing, boating, recreation, tourism, and prime residential development. In the lower reach of the estuary there are a number of ports for commercial and deep-sea sport fishing fleets. The lower reach is also a haven and service point for large recreational cruisers traveling the Intracoastal Waterway.

ENVIRONMENTAL PROBLEMS

In recent years the environmental condition of the Loxahatchee River and estuary has become a subject of major concern to many citizens and agencies of the state. A great deal of controversy has arisen over questions about the environmental well-being of the river and estuary, as well as certain management proposals and decisions related to these water bodies (Cary Publications, Inc., 1978).

One of the major concerns is focused on the northwest fork and the central reach in the lower part of the estuary. The northwest fork from river mile 13 (State Road 706) to river mile 10 is one of the last remaining stretches of a natural subtropical river in south Florida. In May 1977, President Carter proposed to Congress that a study be made by the Department of the Interior to determine if the Loxahatchee River should be included in the National Wild and Scenic Rivers System. Subsequently, legislation passed the Congress (Wild and Scenic Rivers Act as amended through Public Law 95-625, November 10, 1978) to consider designating the Loxahatchee River, among other rivers, for inclusion in the system. The Loxahatchee River presently is being studied by the National Park Service for inclusion in the National Wild and Scenic Rivers System.

The Loxahatchee River originally received flow into its northwest fork from the Loxahatchee Marsh and the Hungryland Slough. Both of these drained north from the low divides near State Road 710 (Parker and others, 1955). Canal 18 was constructed in these natural drainage features and diverted their flow to the southwest fork of the estuary. Because this diversion would probably be detrimental to the freshwater vegetation in the northwest fork, a culvert was placed in Canal 18 in the early 1970s, so that up to 50 ft^3/s could be redirected to this fork.

Increased seawater encroachment may be responsible for changes in vegetation in the Loxahatchee wetlands (Alexander and Crook, 1975). Of particular concern is the health of the bald cypress forest. Most cypress trees closest to the ocean are dead; farther inland numerous trees, if not dead, appear to be stressed. In the upper reaches at the head of tidewater, most trees appear healthy.

Another concern is focused on the kind and amount of suspended sediment transported to the estuary by Canal 18 (Moore, 1979). Large amounts of suspended sediment that settle in an estuary might smother bottom life or alter circulation patterns. If the sediment is largely organic, oxygen supplies near the bottom might be depleted. Also, suspended sediment can transport pollutants, such as heavy metals and pesticides, that absorb on the sediment particles. Pollutant buildup might occur where sediments are deposited.

Agricultural and urban growth in the basin also pose a threat to water quality in the river and estuary. Nutrients, pesticides, and toxic metals may be flushed into the estuarine waters and accumulate in the sediment and biota. In addition, sewage effluent from an advanced wastewater treatment plant discharges to a pond near the northwest fork of the river. Plans call for an increase from 300,000 gal/d to 4 Mgal/d.

Sediment transported from tributaries or from the ocean may also accumulate in shoals that impede boat traffic. In turn, construction of channels to accommodate boats can be environmentally harmful, particularly where these channels cross sea grass beds.

NEEDS

Environmental and resource information is needed to help solve problems in the Loxahatchee River basin and estuary and to provide management alternatives. Information needs relate to seawater encroachment, sedimentation, and pollution in the estuary. Measurements are needed on the input, output, and circulation of water, salt, sediment, and pollutants, and on the effects these have on the biology and overall quality of the estuary. By knowing the input and sources of materials and their effects on estuarine biology, managers can have alternatives in changing the flux of materials to protect or improve environmental quality. To provide the needed information, an in-depth environmental investigation has been planned.

PLANNED INVESTIGATION

To discuss the possibility of an in-depth environmental investigation in the Loxahatchee River estuary, 15 local, State, and Federal agencies met in Tequesta, Florida, on November 8, 1977. At the meeting, sponsored by the Jupiter Inlet District, the U.S. Geological Survey was called on to describe a comprehensive estuarine investigation. It was generally agreed that an investigation was needed, and that the U.S. Geological Survey should conduct the investigation.

During subsequent meetings sponsored by the Jupiter Inlet District, representatives of various governmental agencies discussed the proposed Loxahatchee River estuary investigation. The U.S. Geological Survey was requested to develop a work plan during May to October 1979, and to begin the investigation October 1, 1979.

The objectives of the U.S. Geological Survey Loxahatchee River estuary assessment are to:

1. Define the basin characteristics in terms of drainage divides (subbasins), land cover and land use, and soil type;
2. Study the major input and output patterns of water, sediment, and selected chemical constituents to and from the estuary, and the transport of these items within the estuary;
3. Provide baseline information on the bottom sediment, sea grass beds, and wetlands, and on areal, tidal, and seasonal patterns of water quality within the estuary;
4. Analyze selected functions and interrelationships within the estuary in terms of water, sediment, chemical input and output, basin characteristics, circulation, water quality, and biology.

PURPOSE AND SCOPE

This map report represents the first published product of the Loxahatchee River estuary assessment, and primarily fulfills the first objective as outlined above. It presents an overview of the major physical features of the basin and presents selected information on the U.S. Geological Survey assessment. The report includes a photomosaic map (fig. 3) with the names of major tributaries, the location of selected U.S. Geological Survey stations, basin and subbasin boundaries, and direction of surface-water flow. The scale of the map (1 inch = 1 mile) allows a synoptic view with adequate detail of physical features. The report also includes information on the types of soil and land use in the basin and on characteristics of the estuary. The map report provides a work base for future interpretive reports.

ACKNOWLEDGMENTS

The map report was prepared in cooperation with the Florida Department of Environmental Regulation, Palm Beach County, Martin County, the South Florida Water Management District (SFWMD), Jupiter Inlet District, Loxahatchee River Environmental Control District, Town of Jupiter, Village of Tequesta, Jupiter Inlet Colony, and the U.S. Army Corps of Engineers.

We thank Alan Hull, James Lane, and Linda Haunert of the SFWMD for their advice and information on basin boundaries and waterflow. John Chonke, South Indian River Water Control District, Kenneth Ferrari, and Edward Panaro also provided this type information. We thank Samuel McCollum, Soil Conservation Service, for his help on soils and Lt. Richard Roberts, District Naturalist, Jonathan Dickinson State Park, for his information on waterflow in the park.

METHODS

The photomosaic was produced by Antonio Jurado from color infrared photographs taken by Mark Hurd at about 45,000 feet on March 9, 1979. The U.S. Geological Survey 1:24,000 topographic maps reduced to the map scale 1 inch = 1 mile, were used for horizontal control. Selected hydrologic, topographic, and cultural features from the topographic maps and from other sources were delineated on a clear overlay and photographically composited with the photomosaic at a scale of 1:63,500.

The delineation of the basin and subbasin boundaries was based on land-altitude data on the 1:24,000 topographic maps, boundaries from a SFWMD map (1975), field surveys, and information from knowledgeable individuals.

Land use and land cover in the basin, based on 1979 aerial photography, was provided by the SFWMD. The hierarchical system of land classification is slightly modified from that developed by Anderson and others (1976).

Information on soils in the basin and their classification were provided by the U.S. Soil Conservation Service (S.M. McCollum, written commun., 1979). The percentages of each soil association were determined from General Soil Maps of Martin and Palm Beach Counties.

HYDROLOGIC BASIN AND SUBBASINS

The Loxahatchee River basin covers about 210 mi^2, and is defined by both topography and manmade features, including canals, levees, and roads, and by water-management practices. Historically the basin probably covered about 270 mi^2 and was defined solely by its topography.

The basin is subdivided into nine subbasins based on topography, manmade features, and water-management practices. The subbasins range in size from about 3 to 117 mi^2.

LAND COVER AND LAND USE

About 50 percent of the Loxahatchee River basin is wetland (table 1). Forested, freshwater wetlands cover 2.1 mi^2, primarily along the forks of the Loxahatchee River and its tributaries. The nonforested, freshwater wetlands cover 6 mi^2, mostly in the Loxahatchee Slough of subbasin 9. Mixed forested and nonforested wetlands are by far the dominant category and cover 98.5 mi^2. This category includes large areas of slash pine and wet prairie.

Wetlands occupy significant percentages of subbasins 1 (58 percent), 3 (39 percent), 5 (36 percent), and 9 (69 percent).

Urban and built-up land covers about 17 percent of the basin. Most of this land is classified as "open and other" (table 1), which includes golf courses, parks, recreation facilities, cemeteries, undeveloped within-urban areas, and areas under development. Areas under development account for 52 percent of the urban open land and 38 percent of the total urban land. Ninety percent of subbasin 8 is open and being developed.

Residential land covers 3 percent of the basin, most of which is clustered near the estuary in subbasins 1, 2, 3, 6, 8, and 9. Most residential development is in single-family, low- to medium-density housing.

Agricultural land covers about 18 percent of the basin. Most of this is improved pasture. Of the land classified as "orchards, groves," and so forth, most is in citrus (7.2 mi^2), and the remainder in ornamentals. Cropland is exclusively truck crops.

Forested uplands cover about 13 percent of the basin, most of which is slash pine flatwoods. However, sand pine grows on the coastal ridge in subbasin 1 and accounts for about 1.4 mi^2 or 7 percent of the total coniferous forested uplands. Mixed forest, including old fields that are overgrown and tropical hammocks, account for the remaining 6.8 mi^2 of forested uplands.

SOIL ASSOCIATIONS

Poorly drained, sandy soils dominate the Loxahatchee River basin. A description of soil groups and their soil associations in the basin is given in table 2. A soil association has a distinctive proportional pattern of soils which normally consists of one or more major soils and at least one minor soil (McCollum and others, 1978). Table 2 lists the percentages of soil associations in each subbasin.

Subbasins 1 and 2 contain a much higher percentage of well-drained soils than do the other subbasins. Much of subbasins 1 and 2 are covered by the excessively drained, sandy Paola-St. Lucie soil association. This association is characteristic of the coastal ridge. Some of the Paola-St. Lucie area is in urban use, and some is in native vegetation.

The poorly drained, sandy Wabasso-Riviera-Oldsman association dominates subbasins 3, 4, and 5. Much of the area of this soil association is in native vegetation, but some is used for citrus and other agricultural products. A high water table limits most agricultural uses, unless drainage is provided.

The poorly drained, sandy Waveland-Lawnwood soil association dominates subbasins 6 and 7. Soils in this association are not generally suited for agriculture without water control. Also, most urban uses are severely limited.

The poorly drained, sandy Pineda-Riviera-Wabasso soil association dominates subbasins 8 and 9. Much of this association is in native vegetation, which includes slash pine and wet prairie communities. Some areas are used for citrus, croplands, and pasture. The major soils of the association are severely limited for most agriculture by a high water table, but with adequate water control, they are suitable for agricultural development.

The poorly drained Winder-Tequesta soil association is in the Loxahatchee Slough area of subbasin 9. This association, which makes up about 10 percent of the subbasin, is characterized by long periods of flooding. Most of this association is in native swamp and slough vegetation.

ESTUARINE CHARACTERISTICS

The Loxahatchee River estuary is a shallow water body with a surface area of about 2 mi^2. Water depths slightly exceed 15 feet near Jupiter Inlet, but much of the estuary is less than 5 feet deep. Channels in the southwest and northwest forks exceed 10 feet. Most of the deeper parts of the estuary have been dredged.

The Loxahatchee River estuary is a natural feature maintained by tides and freshwater discharge. Early Spanish maps and the Jonathan Dickinson Journal, published in 1699 (Andrews and Andrews, 1975), first described the estuary and its inlet. During its history the inlet has periodically closed, and the estuary at times reverted to a freshwater environment (Vines, 1970).

Tides and freshwater discharge determine salinity in the estuary. Tides are semidiurnal. The mean range just inside Jupiter Inlet is about 2.5 feet, and the mean spring tide range is about 3 feet (fig. 4). Tidal range just outside the inlet is about twice as large as the range in the estuary (Chiu, 1975). Tidal fluctuations in the northwest fork extend more than 10 miles up the river.

Salinity of the Loxahatchee River estuary ranges from that of seawater (36 parts per thousand) to freshwater. For the first 1 to 2 miles inland from Jupiter Inlet, salinity is usually slightly less than that of seawater. Despite the relatively shallow depth of the estuary, pronounced vertical stratification may occur (fig. 5).

Salinity patterns in the three forks of the estuary differ. The southwest fork is affected by control structure S-46 and the C-18 canal. The control structure prevents salty water from moving upstream. Downstream of S-46, high salinities may persist throughout the year. Birnhak (1974) reported that mean monthly salinities (1971–72) were about 16 parts per thousand near the surface and 29 parts per thousand near the bottom. Water near the bottom remained salty throughout the year even during periods of freshwater discharge from C-18.

The north fork of the Loxahatchee River estuary is shallower and receives less freshwater inflow than the northwest fork. As a result, the north fork has a more uniform, brackish salinity than the northwest fork.

The northwest fork becomes seasonally fresh during periods of large freshwater inflow and salty during periods of little inflow. With 152 ft^3/s inflow, freshwater conditions prevailed upstream of river mile 6. With 11 ft^3/s inflow, salinity at river mile 6 was half that of seawater, and brackish conditions extended upstream of river mile 9 (fig. 5).

CONVERSION FACTORS

For those readers who may prefer to use metric units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	*By*	*To obtain metric (SI) unit*
inch (in)	1.609	kilometer (km)
foot (ft)	3.048×10^{-1}	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	2.832×10^{-2}	cubic meters per second (m^3/s)
gallon per day (gal/d)	3.785	liter per day (L/d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

National Geodetic Vertical Datum of 1929 (NGVD of 1929)—A geodetic datum, formerly called "mean sea level," derived from determinations of average sea level at 26 coastal tide stations along the Atlantic, Gulf of Mexico, and Pacific over a period of many years. The datum, as a best fit, does not represent local mean sea level at any particular place.

REFERENCES

Alexander, T.R., and Crook, A.G., 1975, Recent and long-term vegetation changes and patterns in south Florida: Part II. South Florida Ecology Study, National Technical Information Service, PB-264-462.

Anderson, J.R., Hardy, E.E., Roach, J.T., and Whitmen, R.E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p.

Andrews, E.W., and Andrew, C.M., (eds.), 1975, Jonathan Dickinson Journal: Stuart, Florida, Valentine Books, 106 p.

Birnhak, B.I., 1974, An examination of the influence of freshwater canal discharge on salinity in selected southeastern Florida estuaries: South Florida Environmental Project: National Technical Information Service, PB-23-610.

Cary Publications, Inc., 1978, The Loxahatchee Lament: Jupiter, Florida, 360 p.

Chiu, T.Y., 1975, Evaluation of salt intrusion in Loxahatchee River, Florida: Coastal and Oceanographic Engineering Laboratory, University of Florida, Gainesville.

Davis, J.H., Jr., 1943, The natural features of southern Florida especially the vegetation, and the Everglades: Florida Geological Survey Bulletin no. 25, 311 p.

McCollum, S.H. Cruz, O.E., Stem, L.T., Wittstruck, W.H., Ford, R.D., and Watts, F.C., 1978, Soil survey of Palm Beach County area, Florida: U.S. Soil Conservation Service, 96 p.

Moore, B.R., 1979, Sediment transport studies Jupiter Inlet, Florida: prepared for Jupiter Inlet District, 15 p.

Parker, G.G., Ferguson, G.E., Love, S.K., and others, 1955, Water resources of southeastern Florida: U.S. Geological Survey Water Supply Paper 1255, 965 p.

U.S. Army Corps of Engineers, 1966, Survey report on Jupiter Inlet, Florida: memorandum report.

Vines, W.R., 1970, Surface water, submerged lands, and waterfront lands: Area Planning Board, Palm Beach County, 182 p.

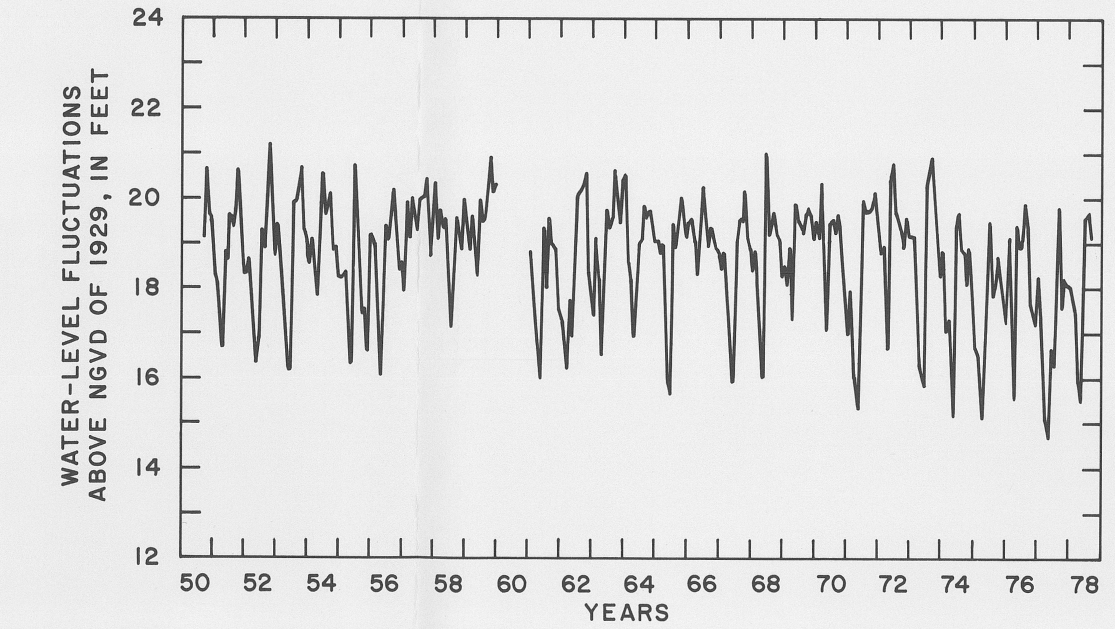

Figure 2.—Water-level fluctuations in a shallow well (M-140) in the Loxahatchee River basin, 1950–78.

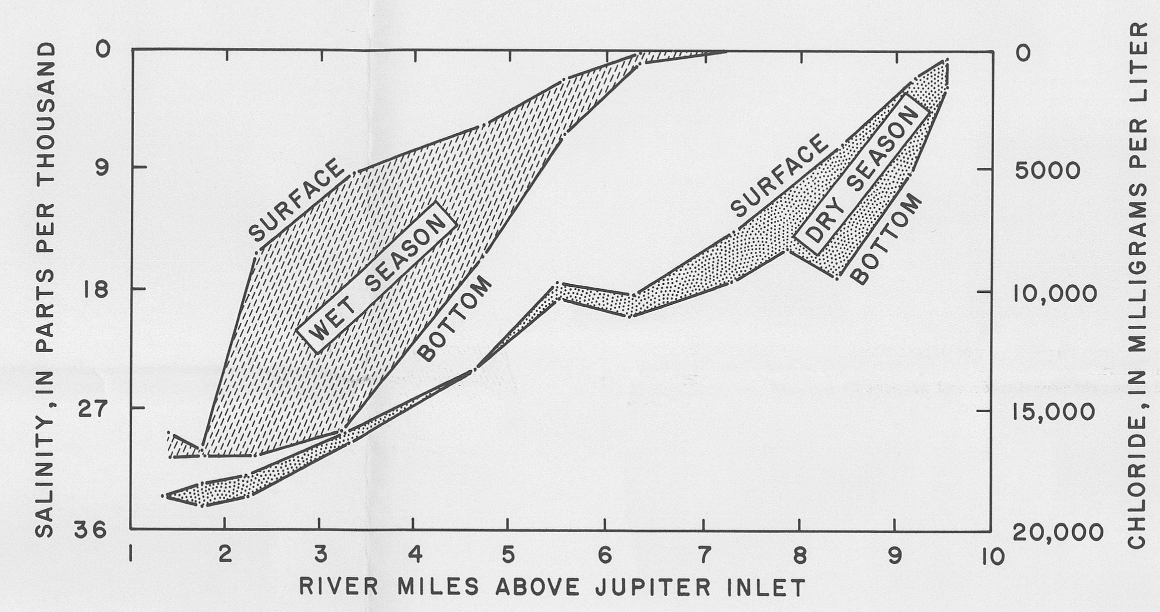

Figure 5.—Salinity transects in the Loxahatchee River estuary and northwest fork, slack high tide, during wet (September 24, 1976) and dry (May 3, 1977) seasons. Measurements near surface and bottom. Mean daily discharges into the northwest fork were 152 cubic feet per second (Sept.) and 11 cubic feet per second (May).

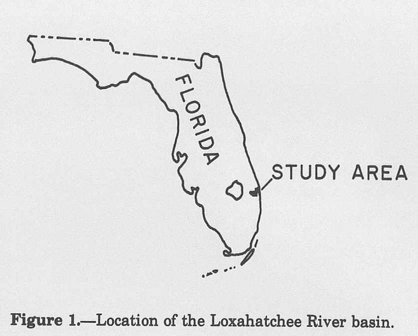

Figure 1.—Location of the Loxahatchee River basin.

Table 2.—Percentages of soil associations in the subbasins

Description and soil associations	Subbasin 1	2	3	4	5	6	7	8	9
Well-drained, sandy soils of Coastal Ridge									
Paola-St. Lucie association	51	64	9	—	—	—	3	—	—
Poorly drained, sandy soils of flatwoods									
Salerno-Jonathan-Hobe[1]	40	24	4	4	4	36	24	—	—
Waveland-Lawnwood	9	12	17	—	4	64	73	2	5
Nettles	—	—	7	4	4	—	—	—	—
Wabasso-Riviera-Oldsman	—	—	63	62	42	—	—	25	19
Pineda-Riviera-Wabasso	—	—	—	30	28	—	—	73	47
Pineda-Riviera-Boca	—	—	—	—	18	—	—	—	19
Poorly drained soils of sloughs and depressions									
Winder-Tequesta	—	—	—	—	—	—	—	—	10

[1]/Salerno-Jonathan-Hobe association has moderately well drained and poorly drained soils.

Table 1.—Land use and land cover in the Loxahatchee River basin, 1979
[Values in square miles]

Land use and land cover	Subbasin 1	2	3	4	5	6	7	8	9	Total
Urban and built up										
Residential	1.5	0.7	0.7	—	—	0.9	1.0	1.2	0.7	6.7
Commercial	.05	—	.05	—	—	—	.03	—	.2	.3
Industrial	.03	—	.03	—	—	—	.07	—	.7	.8
Institutional	—	—	.02	—	—	—	.1	—	—	.1
Transportation	—	—	—	—	0.5	—	.09	.03	1.1	1.7
Open and others	.6	.7	.3	—	—	.2	2.2	10.4	11.2	25.6
Totals	2.2	1.4	1.1	—	.5	1.1	3.5	11.6	13.9	35.3
Agriculture										
Cropland	—	—	.9	1.9	1.7	0.8	—	1.3	1.5	8.1
Pasture	—	—	6.1	1.7	1.4	.4	1.4	1.4	9.3	21.7
Orchards, groves	.01	.02	.6	—	4.3	—	.01	.02	2.7	7.7
Confined feeding	—	—	—	—	—	—	—	—	.1	.1
Totals	.01	.02	7.6	3.6	7.4	1.2	1.4	2.7	13.6	37.5
Forested uplands										
Coniferous	2.3	.7	2.9	.2	7.1	2.9	.8	1.8	1.5	20.2
Mixed forest	—	—	.09	—	.6	—	.08	.4	5.6	6.8
Totals	2.3	.7	3.0	.2	7.7	2.9	.9	2.2	7.1	27.0
Wetlands										
Forested, freshwater	.5	—	.2	.1	.3	.3	—	.2	.5	2.1
Nonforest, freshwater	.3	—	.4	—	—	—	—	—	5.3	6.0
Forested, saltwater	.06	.04	—	.01	—	.2	—	—	—	.3
Mixed forested and nonforested (pine and wet prairie).	6.9	.8	7.2	—	8.7	—	—	.1	74.8	98.5
Totals	7.8	.8	7.8	.1	9.0	.5	—	.3	80.6	106.9
Water, fresh	1.1	.01	.2	.01	—	.5	.3	—	1.0	3.1
Barren land										
Extractive	—	—	.3	—	.1	—	—	.3	.1	.8
Spoil areas	—	—	—	—	—	—	—	—	.3	.3
Totals	—	—	.3	—	.1	—	—	.3	.4	1.1
Totals	13.4	2.9	20.0	3.9	24.7	6.2	6.1	17.1	116.6	210.9

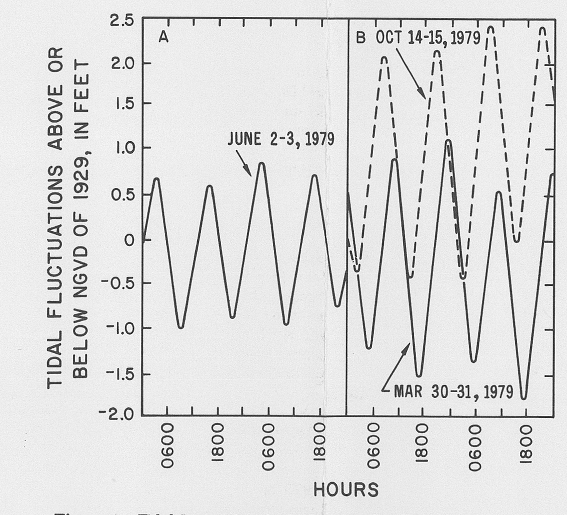

Figure 4.—Tidal fluctuations in the Loxahatchee River estuary (Dubois Park tide gage, Jupiter Inlet).

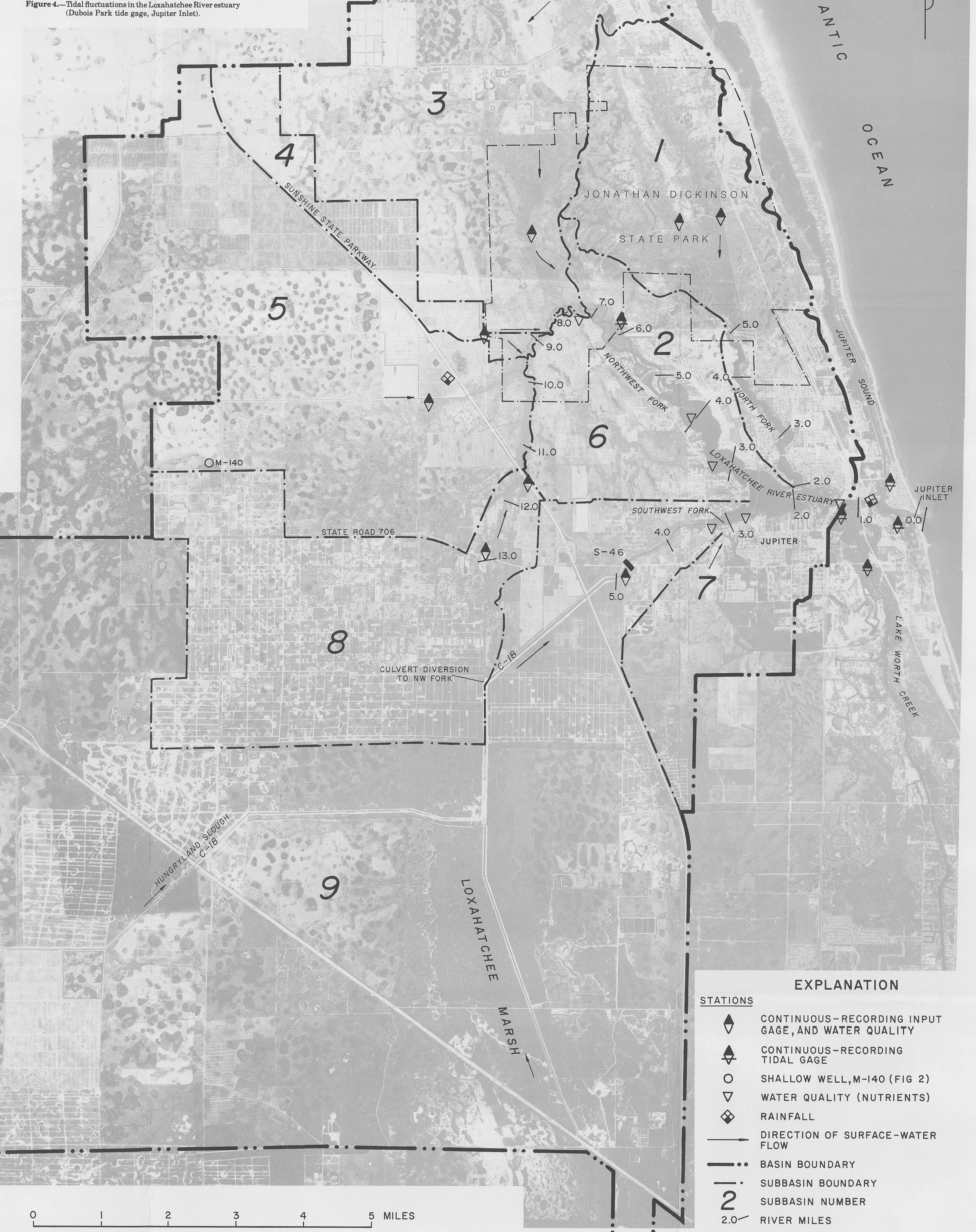

Figure 3.—Hydrologic and land-cover features of the Loxahatchee River basin.

HYDROLOGIC AND LAND-COVER FEATURES OF THE LOXAHATCHEE RIVER BASIN, FLORIDA

By
Benjamin F. McPherson and Maryann Sabanskas

1980